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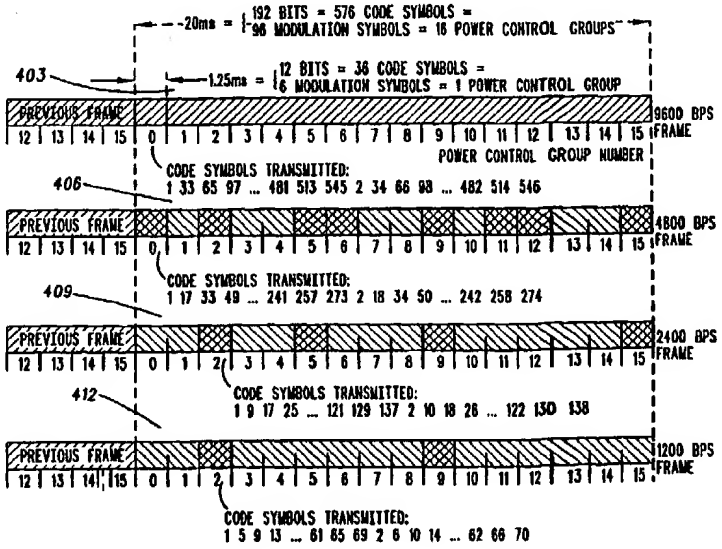

(57) Abstract

A controller (303) determines when user information is not required for transmission and toggles a switch (309) to allow fill information to be transmitted during such times. When user information is required for transmission, the controller toggles the switch such that the user information is transmitted. By filling in the otherwise idle portions during transmission, the pulsing of the transmitter and the negative effects associated therewith are eliminated while the advantage of a pulsing transmitter is maintained.

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APPARATUS AND METHOD FOR CONVEYING INFORMATION IN A COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates generally to communication systems, and, more particularly, to communication systems which employ pulsing transmitters.

BACKGROUND OF THE INVENTION

In certain communication systems which require transmitters to pulse during transmission of information from a source to a destination, the pulsing is known to cause interference to other electronic devices. This problem is commonly referred to as the "hearing aid problem" since hearing aids are one of the electronic devices which suffer from the interference. For example, the mobile station to base-station link (reverse link) in a code-division multiple access (CDMA) communication system compatible with (IS-95), is one type of system which suffers from the problem due to its implementation of variable rate speech coding. Essentially, a variable rate speech coder efficiently a variable amount of output coded speech information depending on the users speech input. For example, during silent passages, a variable rate speech coder will significantly reduce the amount of coded information needed to transmit. Because of the reduced information needed to transmit, the amount of total system interference is reduced since the transmitter is gated intermittently. In such a CDMA system which implements variable rate speech coding, since interference is significantly reduced by this feature system capacity is greatly enhanced.

Other types of communications likewise implement pulsing transmitters to convey information. For example, several

proposed wideband CDMA communications systems in the art exhibit this problem and time-division multiple access (TDMA) communications systems likewise pulse repetitively in order to transmit during particular time slots of a frame. In the TDMA communication systems there are situations where time slots within a particular frame are not utilized, thus during those time slots no information is sent. Again, to accommodate this mode of operation, the transmitter within the TDMA communication system is advantageously gated off to limit system interference and to relinquish the channel for another user's use.

Thus, a need exists for a method and apparatus in a communication system which eliminates the pulsing of a transmitter to eliminate the hearing aid problem while still realizing system capacity increases.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 generally depicts a block diagram of a prior art mobile station transmitter compatible with IS-95A.

FIG. 2 generally depicts a resulting 20 millisecond (ms) frame of information resulting from a variable rate transmission in an IS-95A compatible communication system.

FIG. 3 generally depicts a block diagram of a mobile station which eliminates the effects of pulsing in accordance with the invention.

FIG. 4 generally depicts the resulting frames of information after implementing transmitter pulsing elimination in accordance with the invention.

FIG. 5 generally depicts a typical transmission in an IS-95A compatible communication system.

FIG. 6 generally depicts an alternate embodiment of a narrowband transmission in accordance with the invention.

FIG. 7 generally depicts a block diagram of a receiver implemented in a base-station capable of receiving and processing the signal of FIG. 5 in accordance with the invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Stated generally, a controller determines when user information is not required for transmission and toggles a switch to allow fill information to be transmitted during such times. When user information is required for transmission, the controller toggles the switch such that the user information is transmitted. By filling in the otherwise idle portions during transmission, the pulsing of the transmitter and the negative effects associated therewith are eliminated while the advantage of a pulsing transmitter is maintained.

Stated more specifically, a transmitter for conveying information in a communication system includes means for generating a predetermined pattern to produce fill information and means for determining when user information is not required for transmission. The transmitter further includes means for controlling the transmitter such that the fill information is transmitted when the user information is not required.

In the preferred embodiment, the predetermined pattern represents a narrowband transmission at a predetermined carrier frequency. Additionally, the means for determining when user information is not required for transmission further includes means for determining when user information is not required for transmission based on frame data rate information. The frame data rate information is generated based on either speech information or data information. The means for controlling the transmitter further includes means for controlling a switch to toggle between the fill information and the user information. The fill information and the user information are each at a baseband frequency.

A method of conveying information in a communication system is also disclosed, and includes the steps of transmitting user information during a portion of time of a predetermined time period and transmitting fill information during the remainder of time of the predetermined time period. The step of transmitting fill information further comprises the step of transmitting a signal at a mobile station which is easily removed by a receiver at a base-station, where the signal which is easily removed by a receiver at a base-station further comprises an unmodulated carrier. The step of transmitting fill information during the remainder of time of the predetermined time period is enabled either at a mobile station or a base-station and the step of transmitting fill information during the remainder of time of the predetermined time period further comprises transmitting fill information during idle power control groups in a code-division multiple access (CDMA) communication system or transmitting fill information during idle time slots in a time-division multiple access (TDMA) communication system.

A communication system for conveying information is also disclosed, the communication system comprising a transmitter which itself comprises means for generating a predetermined pattern to produce fill information and means for determining when user information is not required for transmission. Again, a means for controlling controls the transmitter such that the fill information is transmitted when the user information is not required. The communication system further comprises a receiver comprising which includes a means for receiving the user information when the user information and the fill information for a plurality of users and a means for filtering the fill information prior to demodulation.

In this implementation, the transmitter resides in a mobile station and the receiver resides in a base-station. The means for controlling the transmitter such that the fill information is transmitted when the user information is not required is enabled by either a user of the mobile station or by a base-station as a service option. Data representing the service option control for enabling

the capability for a particular subscriber is stored in a database coupled to the base-station.

FIG. 1 generally depicts a block diagram of a prior art mobile station transmitter compatible with IS-95A. The block diagram of FIG. 1 is taken from IS-95A, specifically Figure 6.1.3.1-2 "Reverse CDMA Channel Structure" and the operation of each of the blocks is generally explained in § 6.1.3.1. For more information on IS-95-A, see TIA/EIA/IS-95-A, *Mobile Station-Base Station Compatibility Standard for Dual Mode Wideband Spread Spectrum Cellular System*, July 1993. Referring to IS-95A, §6.1.3.1.7 (variable data rate transmission) describes the implementation and operation of variable rate transmission in the IS-95A system.

FIG. 2 generally depicts a resulting 20 millisecond (ms) frame of information resulting from a variable rate transmission in an IS-95A compatible communication system. The frame timing diagram of FIG. 2 is also taken from IS-95A, specifically Figure 6.1.3.1.7.1-1 "Reverse CDMA Channel Variable Data Rate Transmission Example." As shown in FIG. 2, frame 203 is transmitted at 9600 bits per second (bps) which represents a full rate frame in IS-95A. Frame 206 has half as much information transmitted therein, and is thus called a 1/2 rate frame of information in IS-95A. Frames 209 and 212 transmit 1/4 of the information and 1/8 of the information respectively when compared to the full rate frame 203, and are thus accordingly labeled 1/4 rate frame and 1/8 rate frame, respectively, in IS-95A.

As can be seen with reference to FIG. 2, during the transmission of the full rate frame 203, each power control group (PCG) 0-15 contains information to be transmitted, thus the transmitter during a full rate transmission is never gated off. However, during the other frames 206, 209, and 212 the transmitter of the mobile station is gated off when no information is present. For example, during PCGs 1, 3-4, 7-8, 10 and 13-14 of each frame, no information is present thus the transmitter must be in the off state. However, during those PCGs where information is present (the shaded area of FIG. 2), the transmitter is gated on such that the

information is transmitted during that PCG. The intermittent gating of the transmitter of the mobile station is what causes the "hearing aid problem" as described above.

FIG. 3 generally depicts a block diagram of a mobile station which eliminates the effects of pulsing in accordance with the invention. As shown in FIG. 3, the block diagram of the mobile station shown in FIG. 1 is modified to include a controller 303 which is coupled to switches 309 via a control signal 312. The controller 303 has as input frame data rate information and Long Code Generator information (from the Long Code Generator 123) which are each also input into the data burst randomizer 120. The controller 303 determines which PCGs require information and which do not, and controls the switches 309 accordingly via the control signal 312. During the idle PCGs (the previously empty and gated off PCGs), a pattern generator 306 outputs a predetermined pattern so that the previously idle PCGs now have "dummy" information transmitted therein.

In the preferred embodiment the controller 303 determines which PCGs will be idle during the rate 1/2, 1/4 and 1/8 data transmissions. After this determination, the controller 303 outputs the control signal 312 to control the switches 309 such that the pattern generator outputs the "dummy" pattern during the idle time slots. When control signal 312 is toggled, representing that the PCG is not idle and requires user information therein, the switches 309 are toggled back such that the I and Q inputs are transmitted during the appropriate PCG. The net effect of this control scheme in accordance with the invention is that information is consistently input into the baseband filters 132 and a signal s(t) output from the summing node 135 being generated. The gating of the transmitter (not shown) is eliminated in accordance with the invention.

FIG. 4 generally depicts the resulting frames of information after implementing transmitter pulsing elimination in accordance with the invention. As can be seen from FIG. 4 the frame 403 is exactly the same as the frame 203 shown for the full rate frame.

However, the rate 1/2 frame 406, the rate 1/4 frame 409 and the rate 1/8 frame 412 have a signal filled into the PCGs which were once idle in accordance with the invention. The signal which fills the PCGs in frames 406, 409 and 412 is output from the pattern generator 306 as described above. The switching between the "dummy" information and the user information for the PCGs is likewise described above in accordance with the invention. In the preferred embodiment, the pattern generated by the pattern generator 306 are a constant value and are input into each branch I and Q. This results in an unmodulated carrier at f_c being transmitted during the previously idle PCGs.

In the case of the CDMA communication system compatible with IS-95A the transmitted data spectrum is centered at some carrier frequency f_c and has a bandwidth of approximately 1.25 MHz. This typical transmission in the IS-95A compatible CDMA communication system is shown in FIG. 5 as transmission 503.

Also shown in FIG. 5 (in dotted line form) is the narrow unmodulated carrier transmission 506 resulting from the pattern generated by the pattern generator 306 of another user. The key characteristic of the narrow unmodulated carrier transmission 506 is that the signal used to fill previously idle PCGs is easy to remove at the receiver of a base-station and thus does not add much complexity thereto. Also important to note is that FIG. 5 is not drawn to scale. As the narrow unmodulated carrier transmission 506 spectrum is tiny relative to the overall CDMA transmission 503, the narrow unmodulated carrier transmission 506 can be easily filtered at a CDMA receiver with permanent filtering without any loss of information occurring from the normal data transmissions.

As one of ordinary skill in the art will appreciate, the position of the narrowband transmission, and the number of narrowband transmissions sent during the idle PCGs is variable and is controlled by the pattern generator 303. For example, FIG. 6 generally depicts an alternate embodiment of narrow band transmissions in accordance with the invention. As shown in FIG. 6, transmissions 601-602 are shown as being transmitted Δx

frequency offset away from the carrier frequency f_C. In this implementation, the CDMA receiver which receives the wideband transmission (shown as 503 in FIG. 5) need not have any additional notch filtering circuitry since the narrowband transmissions in this implementation are outside of the 1.25 MHz bandwidth of the signal 503. In another implementation the narrowband transmission could likewise be some Δy frequency offset away from the carrier frequency f_C, where Δy corresponds to an offset where a portion of frequency spectrum is unused and thus available to accept the narrowband transmission. In any case, pulsing transmitting waveforms are eliminated in accordance with the invention.

FIG. 7 generally depicts a block diagram of a receiver implemented in a base-station capable of receiving and processing the multi-user signals of FIG. 5 in accordance with the invention. As shown in FIG. 7, a receiver 700 for a predetermined sector of coverage (Sector$_1$) is shown in FIG. 7. Signals 503 and 506 are shown entering an antenna 703 which provides the signals 503 and 506 to a bandpass filter/receiver front-end 706. In the preferred embodiment the bandpass filter/receiver front-end 706 includes a bandpass filter centered at f_C and having a pass-band of approximately 1.25 MHz. The receiver front-end portion of block 706 includes functions of automatic gain control (AGC), radio-frequency (RF) to intermediate frequency (IF) mixing, IF to baseband mixing, I and Q demodulation, etc. as is well known in the art.

Output from the bandpass filter/receiver front-end 706 are the signals 503 and 506 in the form of I and Q signals which each enter Analog-to-Digital (A/D) converters 709. The A/D converter 709 convert the signals 503 and 506 in the form of I and Q signals from an analog form to a digital representation. The output of the A/D converters 709 are each input into high pass filters 712 to effectively filter out the narrowband transmission signal 506. In the preferred quadrature embodiment, the high pass filters 712 are

digital filters. The effect of these filters is to create a notch at frequency f_c. The cutoff frequency of the high pass filters 712 determines the bandwidth of the effective notch filter and is adjusted to be adequate for clock frequency tolerance and Doppler shifts which are characteristic of mobile signal transmission, preferably about 300 Hz. The output of the filter 712 are input into a multi-branch receiver with speech processing block 715 which is well known in the art. The output of the block 715 is input into a deinterleaver/decoder (not shown) which essentially undoes the interleaving and encoding performed at the mobile station of FIG. 3. By implementing the receiver front end 700 as shown in FIG. 7, the narrowband transmission 506 as generated by the pattern generator of 306 of FIG. 3 is notched out of the spectrum of the wideband CDMA signal 503 in accordance with the invention. As such, by implementing the mobile station shown in FIG. 3 and the receiver shown in FIG. 7, the problems associated with the pulsing of the mobile station are eliminated in accordance with the invention.

The feature of transmitter pulsing elimination in the mobile station in accordance with the invention can be controlled in several different ways. For example, each mobile station can be provided a "hearing aid" button which, when activated, implements the feature. When the "hearing aid" button is inactive, it can be assumed that the user of the mobile station does not use a hearing aid and thus transmitter pulsing as shown in the prior art (FIG. 1 and FIG. 2) is implemented. This allows for battery savings for the user since the transmitter is used only as needed.

Additionally, the feature of transmitter pulsing elimination in the mobile station in accordance with the invention can be controlled by the base-station side (infrastructure) as a service option negotiation by way of exchanging appropriate control messages. For example, when a user begins service with a particular service provider, the user's requirement to implement transmitter pulsing elimination in the mobile station in accordance with the invention is stored at a central database

accessible by each base-station in the system. When the user which requires the feature accesses the communication system, the base-station serving the user queries the central database, determines the user subscribes to such a feature, and activates the feature via the particular wireless air interface (CDMA/TDMA) when the mobile station registers with the communication system. In this control scenario, the user need only worry about implementing the feature when the user subscribes for service, and the system automatically activates the feature when the user uses the communication system.

While the invention has been particularly shown and described with reference to a particular embodiment, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention. The corresponding structures, materials, acts and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or acts for performing the functions in combination with other claimed elements as specifically claimed.

What I claim is:

Claims

1. A transmitter for conveying information in a communication system, the transmitter comprising:

means for generating a predetermined pattern to produce fill information; and

means for determining when user information is not required for transmission and controlling the transmitter such that the fill information is transmitted when the user information is not required.

2. The apparatus of claim 1, wherein the predetermined pattern represents a narrowband transmission at a predetermined carrier frequency.

3. The apparatus of claim 1, wherein the means for determining when user information is not required for transmission further comprises means for determining when user information is not required for transmission based on frame data rate information.

4. The apparatus of claim 3, wherein the frame data rate information is generated based on either speech information or data information.

5. The apparatus of claim 1, wherein the means for controlling the transmitter further comprises means for controlling a switch to toggle between the fill information and the user information.

6. The apparatus of claim 5, wherein the fill information and the user information is at a baseband frequency.

7. A communication system for conveying information comprising:

a transmitter comprising:

means for generating a predetermined pattern to produce fill information; and

means for determining when user information is not required for transmission and controlling the transmitter such that the fill information is transmitted when the user information is not required; and

a receiver comprising:

means for receiving the user information when the user information and the fill information for a plurality of users; and

means for filtering the fill information prior to demodulation.

8. The communication system of claim 7, wherein the transmitter resides in a mobile station and the receiver resides in a base-station.

9. The communication system of claim 7, wherein the means for controlling the transmitter such that the fill information is transmitted when the user information is not required is enabled by either a user of the mobile station or by a base-station as a service option.

10. The communication system of claim 9, wherein data representing the service option control for enabling the capability for a particular subscriber is stored in a database coupled to the base-station.

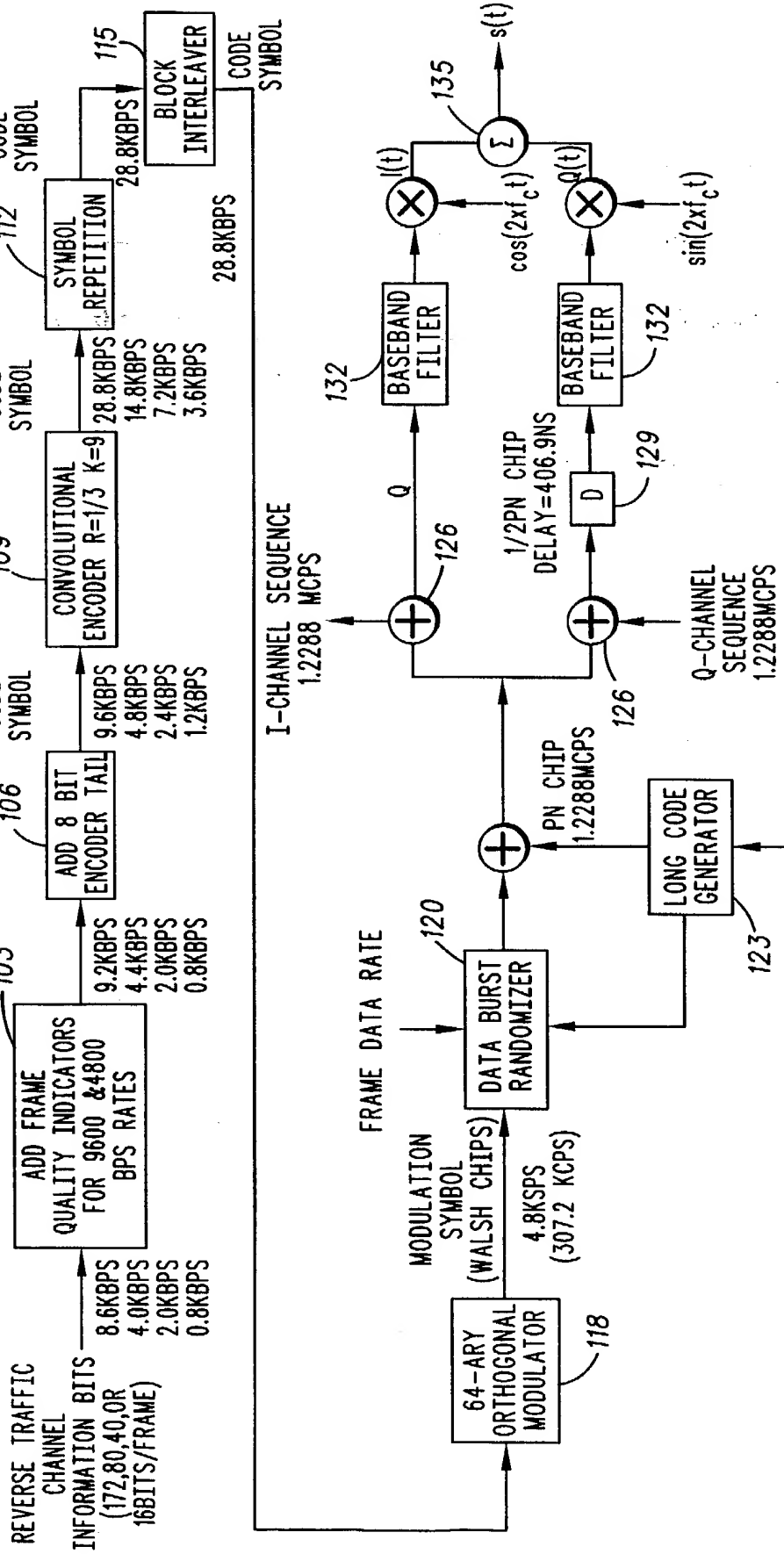
REVERSE TRAFFIC CHANNEL INFORMATION BITS (172,80,40,OR 16BITS/FRAME)
8.6KBPS
4.0KBPS
2.0KBPS
0.8KBPS
ADD FRAME QUALITY INDICATORS FOR 9600 &4800 BPS RATES
103
9.2KBPS
4.4KBPS
2.0KBPS
0.8KBPS
ADD 8 BIT ENCODER TAIL
106
CODE SYMBOL
9.6KBPS
4.8KBPS
2.4KBPS
1.2KBPS
CONVOLUTIONAL ENCODER R=1/3 K=9
109
CODE SYMBOL
28.8KBPS
14.8KBPS
7.2KBPS
3.6KBPS
SYMBOL REPETITION
112
CODE SYMBOL
28.8KBPS
BLOCK INTERLEAVER
115
CODE SYMBOL
28.8KBPS
I-CHANNEL SEQUENCE 1.2288 MCPS
Q-CHANNEL SEQUENCE 1.2288MCPS
LONG CODE MASK
LONG CODE GENERATOR
123
PN CHIP 1.2288MCPS
1/2PN CHIP DELAY=406.9NS
D
129
Q
126
126
FRAME DATA RATE
DATA BURST RANDOMIZER
120
MODULATION SYMBOL (WALSH CHIPS)
4.8KSPS (307.2 KCPS)
64-ARY ORTHOGONAL MODULATOR
118
BASEBAND FILTER
132
BASEBAND FILTER
132
I(t)
Q(t)
cos(2xf_c t)
sin(2xf_c t)
Σ
135
s(t)

FIG.1

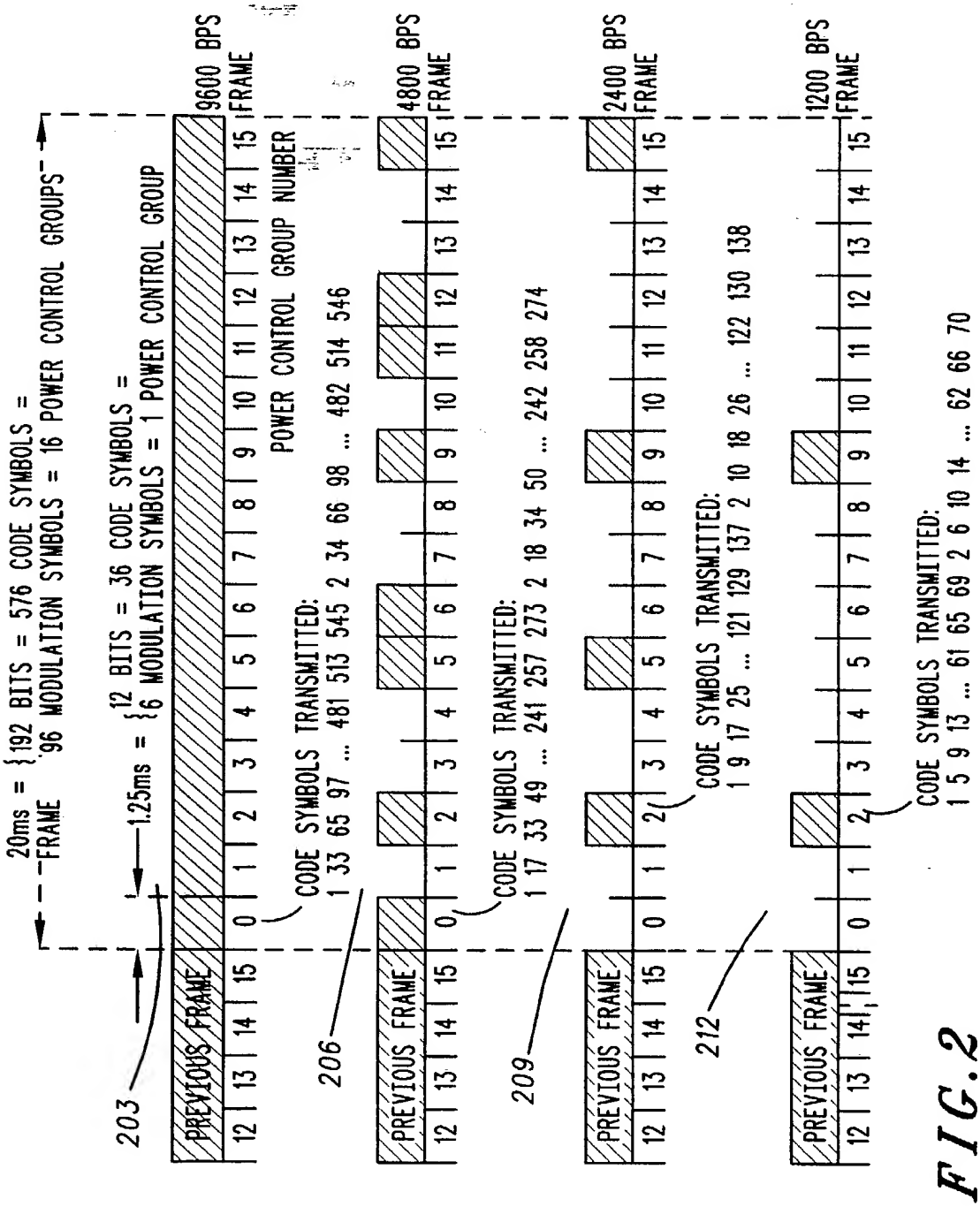
20ms = FRAME
192 BITS = 576 CODE SYMBOLS =
96 MODULATION SYMBOLS = 16 POWER CONTROL GROUPS
1.25ms =
12 BITS = 36 CODE SYMBOLS =
6 MODULATION SYMBOLS = 1 POWER CONTROL GROUP
203
PREVIOUS FRAME
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
9600 BPS FRAME
CODE SYMBOLS TRANSMITTED:
1 33 65 97 ... 481 513 545 2 34 66 98 ... 482 514 546
POWER CONTROL GROUP NUMBER
206
4800 BPS FRAME
CODE SYMBOLS TRANSMITTED:
1 17 33 49 ... 241 257 273 2 18 34 50 ... 242 258 274
209
2400 BPS FRAME
CODE SYMBOLS TRANSMITTED:
1 9 17 25 ... 121 129 137 2 10 18 26 ... 122 130 138
212
1200 BPS FRAME
CODE SYMBOLS TRANSMITTED:
1 5 9 13 ... 61 65 69 2 6 10 14 ... 62 66 70

FIG. 2

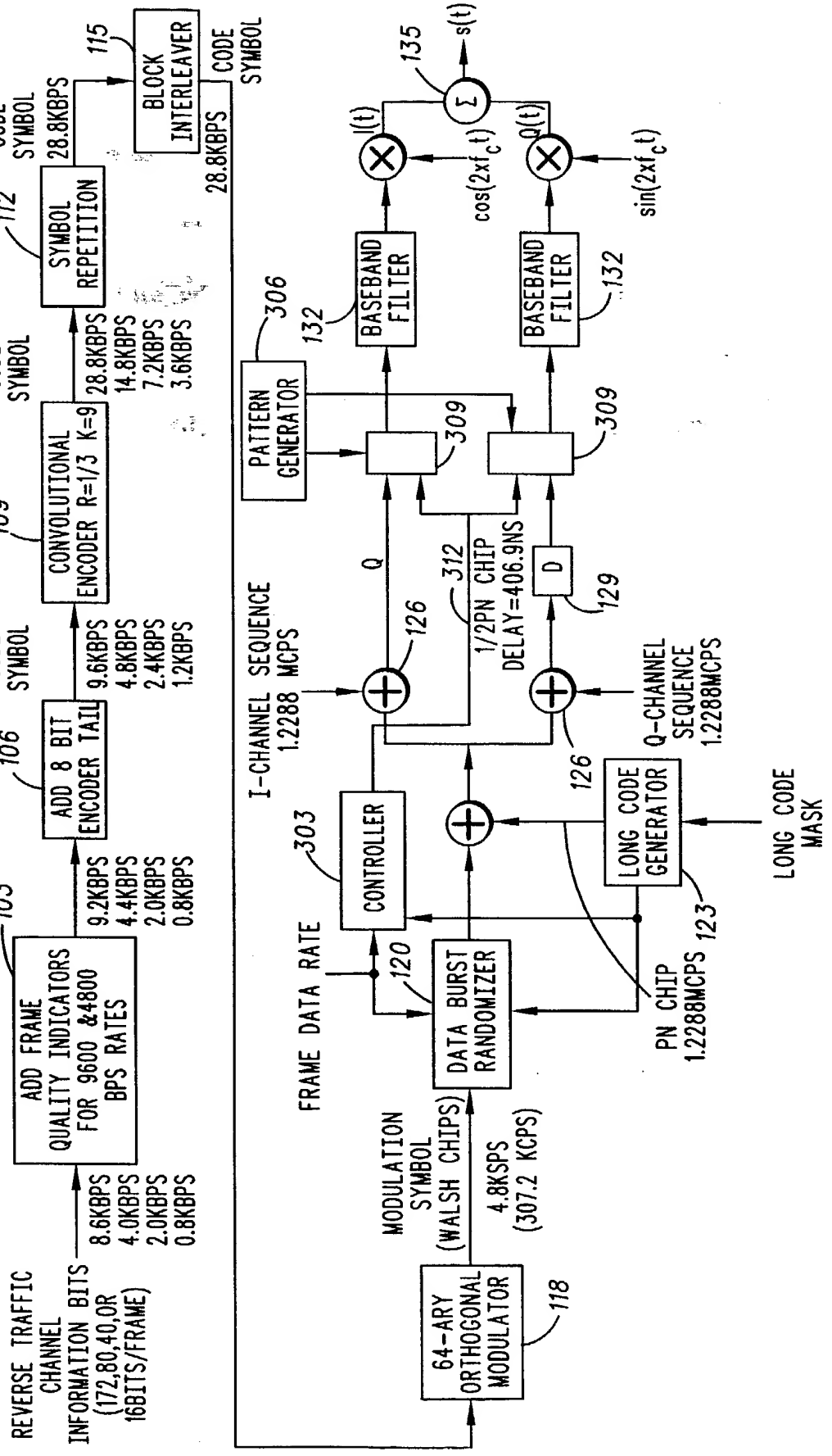
REVERSE TRAFFIC CHANNEL INFORMATION BITS (172,80,40,OR 16BITS/FRAME)
8.6KBPS
4.0KBPS
2.0KBPS
0.8KBPS
103
ADD FRAME QUALITY INDICATORS FOR 9600 &4800 BPS RATES
9.2KBPS
4.4KBPS
2.0KBPS
0.8KBPS
106
ADD 8 BIT ENCODER TAIL
CODE SYMBOL
9.6KBPS
4.8KBPS
2.4KBPS
1.2KBPS
109
CONVOLUTIONAL ENCODER R=1/3 K=9
CODE SYMBOL
28.8KBPS
14.8KBPS
7.2KBPS
3.6KBPS
112
SYMBOL REPETITION
CODE SYMBOL
28.8KBPS
115
BLOCK INTERLEAVER
CODE SYMBOL
28.8KBPS
64-ARY ORTHOGONAL MODULATOR
118
MODULATION SYMBOL (WALSH CHIPS)
4.8KSPS (307.2 KCPS)
DATA BURST RANDOMIZER
120
FRAME DATA RATE
CONTROLLER
303
I-CHANNEL SEQUENCE 1.2288 MCPS
PATTERN GENERATOR
306
LONG CODE GENERATOR
123
PN CHIP 1.2288MCPS
LONG CODE MASK
Q-CHANNEL SEQUENCE 1.2288MCPS
126
Q
I
312
1/2PN CHIP DELAY=406.9NS
D
129
309
309
BASEBAND FILTER
132
BASEBAND FILTER
132
cos(2xf_c t)
sin(2xf_c t)
135
Σ
s(t)

FIG. 3

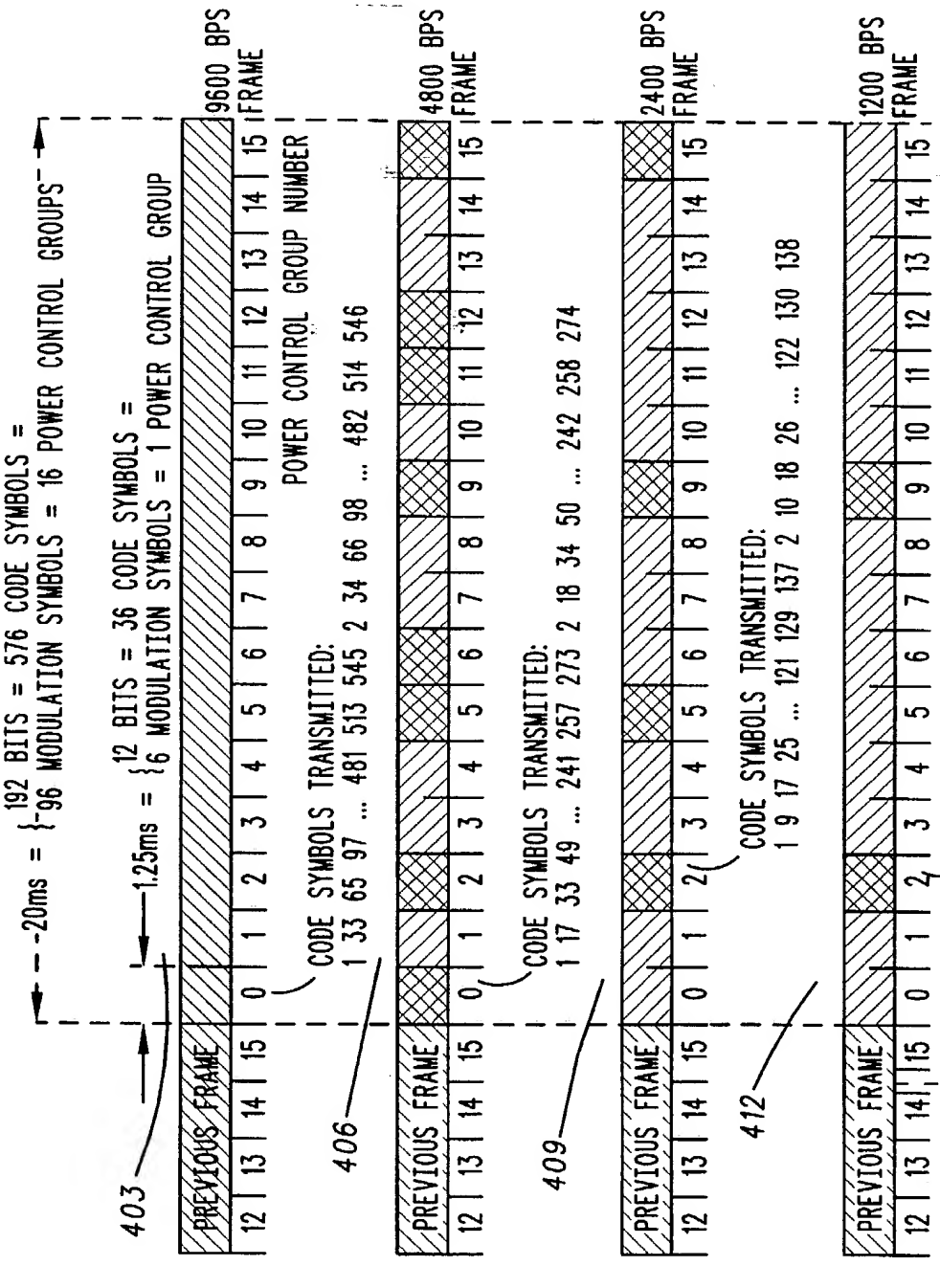
20ms = 192 BITS = 576 CODE SYMBOLS = 96 MODULATION SYMBOLS = 16 POWER CONTROL GROUPS
1.25ms = 12 BITS = 36 CODE SYMBOLS = 6 MODULATION SYMBOLS = 1 POWER CONTROL GROUP
403
406
409
412
PREVIOUS FRAME
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
9600 BPS FRAME
POWER CONTROL GROUP NUMBER
CODE SYMBOLS TRANSMITTED:
1 33 65 97 ... 481 513 545 2 34 66 98 ... 482 514 546
4800 BPS FRAME
CODE SYMBOLS TRANSMITTED:
1 17 33 49 ... 241 257 273 2 18 34 50 ... 242 258 274
2400 BPS FRAME
CODE SYMBOLS TRANSMITTED:
1 9 17 25 ... 121 129 137 2 10 18 26 ... 122 130 138
1200 BPS FRAME
CODE SYMBOLS TRANSMITTED:
1 5 9 13 ... 61 65 69 2 6 10 14 ... 62 66 70

FIG. 4

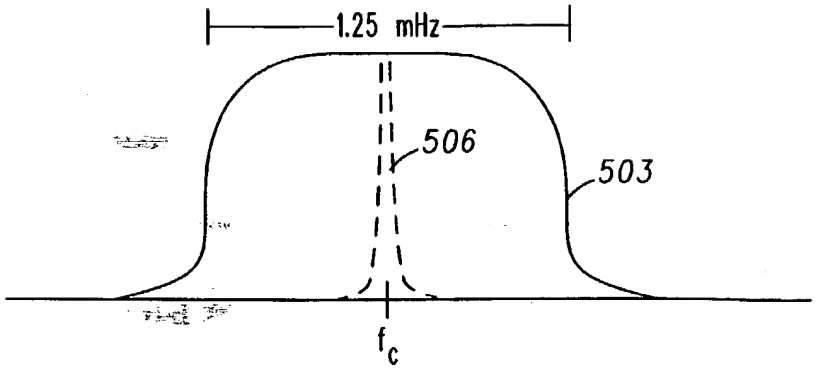

FIG.5

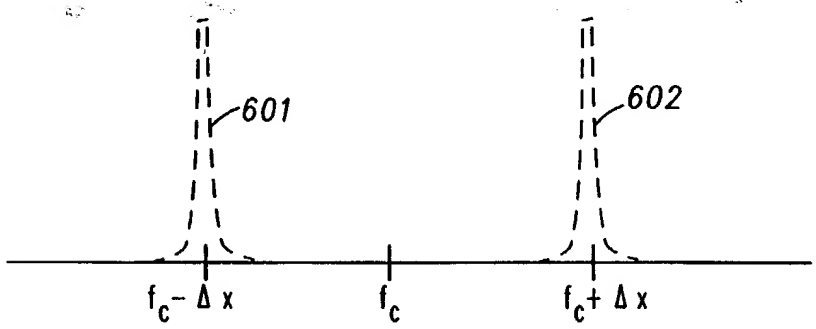

FIG.6

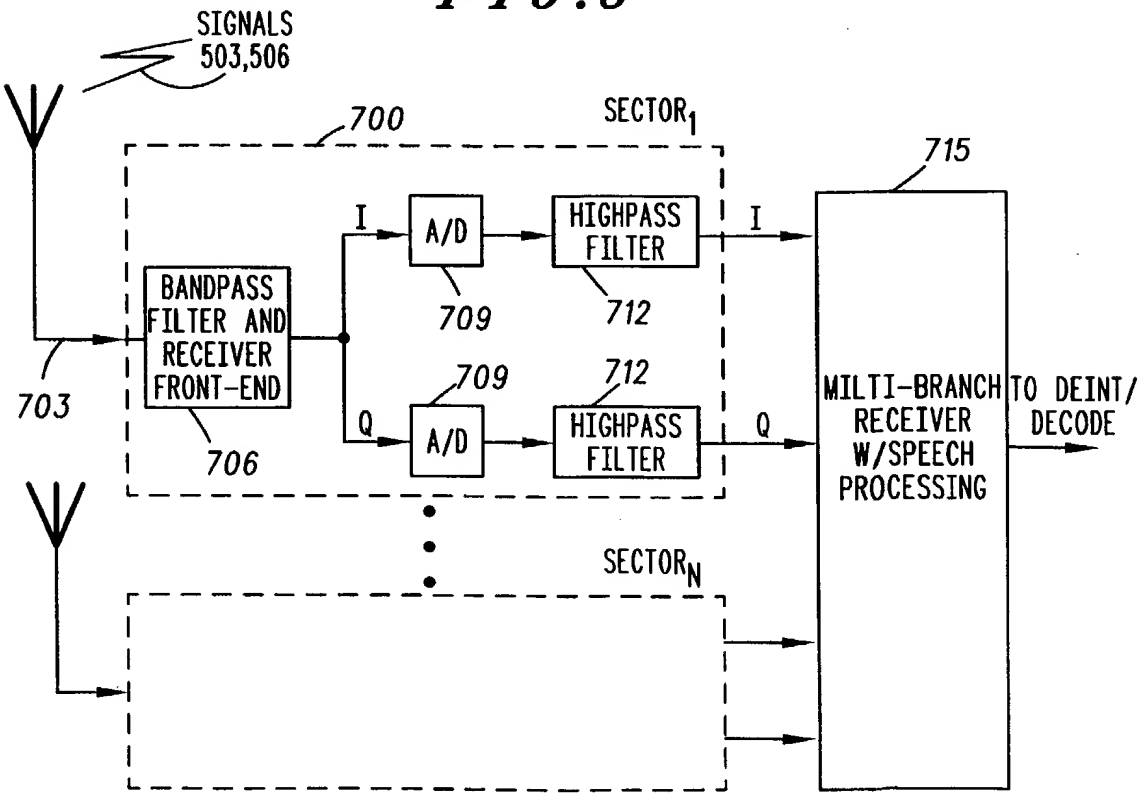

FIG.7